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The Effect of Electron Collisions on Rotational Excitation of Cometary Water

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The e-H_2O collisional rate for exciting rotational transitions in cometary water is evaluated for conditions found in Comet Halley. The e-H_2O collisional rate exceeds that for excitation by neutral-neutral collisions at distances exceeding 3000 km from the cometary nucleus, in the case of the $0_{00} \rightarrow 1_{11}$ transition. The estimates are based on theoretical and experimental studies of e-H_2O collisions, on ion and electron parameters acquired in-situ by instruments on the Giotto and Vega spacecraft, and on results obtained from models of the cometary ionosphere. The contribution of electron collisions may explain the need for large water-water cross-sections in models which neglect the effect of electrons. The importance of electron collisions is enhanced for populations of water molecules in regions where their rotational lines are optically thick.

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The Ephemeris Development Effort for Asteroid 951 Gaspra

D.K. Yeomans (JPL/Caltech)

En route to its encounter with Jupiter, the Galileo spacecraft will fly closely past asteroid 951 Gaspra on October 29, 1991. While the pre-encounter spacecraft images of the asteroid on the star background will be used to dramatically improve the knowledge of its position in the spacecraft - asteroid target plane, the component of its position uncertainty in the spacecraft - asteroid direction will remain relatively unchanged. The spacecraft's close approach time will remain relatively large and can only be improved using ground-based astrometric measurements of the asteroid. Thus, the extent to which the onboard camera must mosaic to successfully image Gaspra will depend upon the accuracy with which its ephemeris can be improved using ground-based astrometric observations. These data now extend back to 1913.

Additional efforts are being made to improve the accuracy of recent astrometric observations including those that will be made throughout the spring and summer of 1991 and end just a few weeks prior to the spacecraft encounter itself. Arnold Klemola (Lick Observatory) and William Owen (JPL) have developed special Lick Observatory reference star catalogs for Gaspra whereby the positions of stars within one degree on either side of its apparent celestial path have been re-determined using either the new PPM catalog (northern hemisphere) or the Perth 70 catalog (southern hemisphere). Within 2' of the asteroid's path, all stars (9-16 mag.) were included in the catalogs while out to 1° on either side of the paths, an approximate density of 27 stars per square degree has been achieved. These special reference star catalogs have been distributed to a group of experienced observers for reducing their astrometric data. As a result of these special star catalog efforts, and the dedication of a small group of astrometric observers, the Gaspra position uncertainty at the time of the Galileo encounter is expected to be less than 200 km.

Using Radar Data to Improve the Orbits of Asteroids and Comets

D.K. Yeomans (JPL/Caltech)

Since the time of the first radar observations of asteroid 1566 Icarus in June 1968, there have been successful radar experiments involving over 60 different mainbelt and near-Earth asteroids (Ostro 1989, *Asteroids II*; Ostro et al. 1991, AJ, submitted). Although the focus of these radar experiments has been to infer the asteroids' physical characteristics from the echoes and properties of the returned signals, corrections to the predicted Doppler and/or time delay ephemerides are also obtained. The measured differences between the transmitted and received frequencies (Doppler shifts) and the round trip time delays can provide extremely powerful data types for the orbit determination of asteroids and comets (Yeomans et al. 1987, AJ, **94**,189).

Radar observation residuals can be typically 1 Hz in Doppler and about a microsecond in round-trip delay time. At the Arecibo transmitter frequency (2380 MHz), these errors correspond to range and velocity errors of 150 m and 6.5 cm/sec. For the Goldstone frequency (8495 MHz), the corresponding velocity error is less than 2 cm/s. The power of the radar data becomes evident when one realizes that radar measurement errors are orders of magnitude smaller than the position and velocity uncertainties inherent in orbits based only upon optical data over short time intervals.

Astrometric radar data effectively measures the object's distance and velocity along the observer's line-of-sight and hence these data are complementary to optical, plane-of-sky measurements. Radar data taken during an object's close approach to the Earth are most powerful, and the orbit refinement most dramatic, if the object has only a short optical astrometric history. A case in point is the recovery of minor planet 1989 PB by M. Hartley, S.M. Hughes and R. McNaught at the Anglo-Australian Observatory on May 3, 1990. Using an ephemeris based upon the 65 available optical position measurements over the interval from 1989 August 1 - 24, the predicted and observed positions of the object on May 3, 1990 differed by 37" in right ascension and 23" in declination. Had an orbit been available that included the 6 Doppler and 6 delay measurements, in addition to the optical observations, the predicted and observed positions differences would have been reduced to 1.4" and 0.8."

For the 30 asteroids and 2 periodic comets for which radar astrometric data was given by Ostro et al. (1991, AJ, submitted), Yeomans et al. (1991, AJ, submitted) computed orbits using both the radar and the existing optical measurements. Ten of these objects were considered by Weissman et al. (1989, *Asteroids II*, 880) to be extinct comets and Yeomans (1991, AJ, in press) found that for at least one of them, 1566 Icarus, the inclusion of a cometlike, outgassing acceleration model was required to successfully fit the observations.

With the relatively recent realization that a large population of near-Earth asteroids are on Earth approaching orbits, there is a critical need to accurately monitor their future motions. For the majority of these objects that lack a long history of optical astrometric data, accurate extrapolations of their motions will require the use of radar data in future orbital solutions.

230 ATHAMANTIS: ROTATION PERIOD AMBIGUITY

Young, James W. and Harris, Alan W.

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Partial photometric lightcurves of the asteroid 230 Athamantis over a 28-year span of time are presented. An original estimated 8 hour rotational rate by the Chinese (Purple Mountain) has been found incorrect, but the remaining two period ambiguities of 12 hours or 24 hours has yet to be determined.

ON DYNAMICAL STRUCTURE OF THE TROJAN GROUP OF ASTEROIDS;

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Using a semi-analytical model, the motions of Trojan asteroids in the three-dimensional elliptic restricted three body problem is considered. Regions where changes of semimajor axes and critical argument (mean longitude of Jupiter minus that of asteroids) occur for various sets of proper eccentricity, proper inclination and longitude of perihelion of asteroids minus that of Jupiter are plotted.

Using an analytical theory, amplitudes and periods of libration, for 70 Trojans has been calculated. Comparison with the results of Shoemaker et.al.(Asteroids II,1989) and of Bien and Schubart (Astron. Astroph.,175,292,1987) have been made, and in most cases good agreement was found. In addition, the possible presence of second order resonance among the real Trojan asteroids had been investigated.

A COMPARISON BETWEEN FAMILIES OBTAINED FROM DIFFERENT PROPER ELEMENTS

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Using the hierarchical method of family identification developed by Zappala' et al. (Astron.J.,100, 2030, 1990) we compare the results coming from the data set of proper elements computed by Williams (about 2100 numbered + about 1200 PLS II asteroids) and by Milani and Knezevic (5.7 version, about 4200 asteroids). Apart from some expected discrepancies due to the different datasets and/or low accuracy of proper elements computed in peculiar dynamical zones, a good agreement was found in several cases. It follows that these high reliability families represent a sample which can be considered independent on the methods used for their proper elements computation. Therefore, they should be considered as the best candidates for detailed physical studies.

Introduction: The Science Instruments of HST

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NO ABSTRACT AVAILABLE

Some Interesting Targets for Future Work

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NO ABSTRACT AVAILABLE

A CANDIDATE FOR THE PARENT BODY OF THE TAURID COMPLEX AND ITS SEARCH EPHEMERIS; K. Ziolkowski, Space Research Centre, Bartycka 18, 00-716 Warszawa, Poland

Untypical asteroid 5025 P-L, which has its perihelion close to the orbit of Mercury and its aphelion between the orbits of Jupiter and Saturn, seems to be a good candidate for the parent body of the Taurid complex of small interplanetary objects. Evidences that this asteroid is a major source of meteoroids as well as an analysis of the orbits of asteroidal and cometary members of the Taurid complex presented in the paper, lead to conclusion that 5025 P-L might be regarded as a remnant of a giant comet which was a progenitor of the overall complex according to the hypothesis of Clube and Napier. Unfortunately, the orbit of 5025 P-L is very poorly determined because the computations were based upon only three positional observations over an arc of only four days in October 1960. Any further research on the problem of origin and evolution of the Taurid complex needs better determined orbit of this key asteroid. Therefore its new positions are necessary. In order to enable the search of eventual trails of 5025 P-L on the plates which can be found in archives, its ephemeris for the opposition in 1960, when the asteroid passed about 0.5 AU from the Earth, is presented.

CoMA - a high resolution time-of-flight secondary ion mass spectrometer (TOF-SIMS) for in situ analysis of cometary matter

H. Zscheeg, J. Kissel, Gh. Natour

Introduction

To shed some light on the origin and history of comets and thus on the formation of the solar system, a detailed in situ analysis of the elemental, isotopic and molecular composition of solid and gaseous cometary - and therefore pristine - matter is highly desirable. The cometary matter analyzer CoMA being developed for the NASA 9 year cometary rendezvous and asteroid flyby mission (CRAF), will meet this desire by examining dust grains and gas originating from a comet, probably Tempel 2. CoMA is a contribution of the FRG.

The goals

CoMA will perform the analysis of cometary samples with an unprecedented mass resolution for a space instrument. Thus it will be able to separate the isotopes of a number of light elements (H, Li, C, Mg) and also to minimize the effects of molecular interferences. This translates to a resolution >3000 at 13 da and >13000 at 350 da. CoMA will comprise a mass range up to 3000 da.

To achieve this, the instrument consists of three basic units: the dust collector subsystem, the primary ion gun and the time-of-flight mass spectrometer.

The dust collector subsystem accommodates about 120 target devices of different structures . It will mechanically move the targets from the collect- to the store-, sputter- and analyze-positions and also add to the electric scan capability of the ion source a mechanical one.

The high brightness liquid metal primary ion gun /2/ produces 10 keV 1 ns pulses of isotopically pure ^{115}In ions and forwards them into a 20 um spot on the sample. A DC mode is used for erosion purposes.

The time-of-flight mass spectrometer is able to compensate for second order flight time variations originating in the energy spread of the secondary ions by using a two staged ion reflector /1/. Folding of the ion flight path by implementing an additional ion mirror reduces geometric dimensions.

Status of CoMA

The feasibility of the basic design was verified by a first model, using components of standard mechanical precision and a 3 ns pulse UV-laser for secondary ion production.

Measurements with a second model basically resembling the flight unit were successful. A similar model underwent first vibration tests.

The primary ion gun in its present state can deliver 2.8 ns ion pulses generated by a combination of scanning the DC-beam across an aperture and subsequently bunching the emerging pulses.

Also under way is the development of an efficient secondary ion detector, a chevron type channelplate assembly with integrated amplifier.

Time measurement electronics evolve on a digital and an analog track. The digital version is centered around a delay line and the analog one around ramp generators. Presently both versions are capable of flight time measurements of 1ns accuracy.

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/2/ J. Kissel, H. Zscheeg and F. G. Ruedenauer: "Pulsed Operation of a Liquid Metal Ion Source" Appl. Phys. A 47, 167-169, (1988)

Author Index

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